TRUSTED NETWORK-BRIDGING TIES:
A DYADIC APPROACH TO THE BROKERAGE-CLOSURE DILEMMA

Daniel Z. Levin
Management and Global Business Department
Rutgers Business School – Newark and New Brunswick
Rutgers University
1 Washington Park
Newark, NJ 07102
Phone (973) 353-5983, Fax (973) 353-1664
levin@business.rutgers.edu

Jorge Walter
Department of Strategic Management and Public Policy
School of Business
The George Washington University
2201 G Street, NW, Funger Hall 615
Washington, DC 20052
Phone: (202) 994-7908, Fax: (202) 994-8113
jorgew@gwu.edu

Melissa M. Appleyard
Ames Professor in the Management of Innovation and Technology
School of Business Administration
Portland State University
P.O. Box 751
Portland, OR 97207
Phone (503) 725-9581, Fax (503) 725-5850
melissaa@sba.pdx.edu

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ABSTRACT

We propose and test a novel solution to the brokerage-closure dilemma that combines the network and dyadic (relationship) levels of analysis. Specifically, we argue that tie strength can act as a substitute for the benefits of network closure, and so a network-bridging tie will yield more useful knowledge when it is also a strong tie. We further disentangle the mechanism underlying the beneficial effect of tie strength by formulating three hypotheses on interaction frequency, emotional closeness, and relational trust. Using hierarchical linear modeling (HLM) on a sample of 408 knowledge-seeking relationships in a large U.S. engineering firm, we find that relational trust has the largest positive impact, whereas emotional closeness has a much more limited impact and interaction frequency actually seems to inhibit the value of a bridging tie. Finally, we find that many bridging ties are trusted, thereby allowing knowledge seekers to “unlock” the value embedded in these ties.

Keywords:
Social networks, structural holes, tie strength, trust, knowledge transfer
Generating and making use of new knowledge can be a source of competitive advantage (Argote, 1999; Grant, 1996; Zander & Kogut, 1995), and hence the cultivation of effective knowledge-transfer relationships—to develop and obtain this knowledge—is essential. Such relationships, in the aggregate, have been studied extensively in the literatures on social networks and social capital. For example, these literatures have established the benefits of brokering between disconnected parties for generating novel insights (e.g., Burt, 1992, 2004). Yet knowledge seekers can sometimes face a dilemma in that this network structure affords novelty but often impedes knowledge transfer. Specifically, when relationships among actors are not surrounded by mutual third parties, i.e., when they lack network closure (Coleman, 1988, 1990; Granovetter, 1985), then the willingness to cooperate may be diminished—and this may in turn hinder the transfer and absorption of new knowledge (Burt, 2005). In a sense, the very network structure most likely to provide access to novel knowledge can sometimes be ill-suited for the cooperation needed to successfully transfer that knowledge.

Recent studies have examined several possible approaches to this “brokerage-closure dilemma” (see Burt, 2005; Reagans & McEvily, 2008 for recent reviews). All of these, however, involve extensive adjustments at the network level—either to the overall network structure, i.e., the pattern of relationships among a set of actors, or to the network’s composition, i.e., the types of actors in a network characterized in terms of their stable traits, features, or resource endowments (Phelps, 2010; Wasserman & Faust, 1994). Such network-level adjustments are likely to be complicated, time-consuming, and difficult, if not impossible, for individuals to achieve on their own. The role that the characteristics of a given relationship can play in resolving this network dilemma has largely been overlooked, however. As Moran (2005: 1132) observed, “Unfortunately, dyad-specific qualities of social capital have been given much less empirical attention [and] have not been empirically disentangled from social capital’s structural attributes.”
Addressing this gap in the literature, we argue that—although the surrounding network structure can and does affect how people feel about each other (e.g., Paxton & Moody, 2003)—not all significant features and benefits of a relationship (i.e., dyad) derive from the surrounding network structure. At the dyad level, the strength of a relationship can provide similar benefits and thus substitute for network-level closure, which tends to engender a sense of cooperation and sharing (Coleman, 1988, 1990; Granovetter, 1985). Applying this insight to the brokerage-closure dilemma, we propose that a network-bridging tie—i.e., a tie that links two parties who share few or no third-party contacts in common—that is also a strong tie can provide both access to novel knowledge (by virtue of its bridging qualities) and the willingness to cooperate (by virtue of its strength). More specifically, given the theoretical (Krackhardt, 1992) and empirical ambiguities (Marsden & Campbell, 1984) surrounding the concept of tie strength, we further strive to disentangle and pinpoint the dyadic mechanism—i.e., interaction frequency, emotional closeness, or relational trust—that is responsible for enhancing the knowledge value of network-bridging ties.

By examining the interplay between network structure and the characteristics of a given tie, we are able to provide a simple but novel, dyadic approach to the brokerage-closure dilemma. Moreover, dyadic characteristics like interaction frequency, emotional closeness, and relational trust can be developed and cultivated independent of the network structure, e.g., when two people spend time together, have things in common, act in a trustworthy manner, etc. (Dwyer, 2000; Levin, 2008), thus making this dyadic approach particularly appealing to network actors.

**THEORY AND HYPOTHESES**

Individuals benefit from being embedded in networks of relationships, which can provide them with preferred access to knowledge flows (Burt, 1992; Granovetter, 1973). For our pur-
poses, we define useful knowledge as information and/or advice that is actionable by recipients, i.e., that can be used to improve their performance on some task or project (Cross, Borgatti, & Parker, 2001; Cross & Sproull, 2004).

The early literature on social capital recognized two competing perspectives as to which type of network structure is more beneficial to knowledge acquisition. The brokerage view emphasized the benefits of obtaining diverse, novel knowledge by brokering across a structural hole, i.e., across otherwise disconnected clusters in a social network (Burt, 1992, 2001). The closure view, in contrast, stressed the benefits of interacting with others in a dense network, where close-knit connections are governed by social norms and reputation effects that encourage support, cooperation, and the exchange of information (Coleman, 1988, 1990).

Although the premise that brokerage and closure are in opposition and create a trade-off among their associated benefits was widely subscribed to in the early literature, recent research suggests several possible resolutions for this dilemma (see Burt, 2005; Reagans & McEvily, 2008 for reviews). The first option is to take a contingency approach, choosing brokerage for certain situations, closure for others. For example, Moran (2005) found that network closure enhanced managers’ performance at more routine, execution-oriented tasks but did not have a significant effect on new, innovation-oriented tasks.

This first option faces the limitation, however, that oftentimes the benefits of both brokerage and closure would be helpful. This leads to a second option: “hybrid” network positions (Baum, van Liere, & Rowley, 2007), such as when a “group consists of people strongly connected to one another, with extensive bridge relations beyond the group” (Burt, 2005: 165). Such

1 Brokerage can include both an individual network actor being a broker at the nodal level (e.g., Reagans & McEvily, 2008) as well as bridging ties between disconnected others at the dyadic level (e.g., Baum, McEvily, & Rowley, forthcoming).
a group could reap the benefits of closure inside the group and the benefits of brokerage beyond the group (Reagans & McEvily, 2008; Walter, Lechner, & Kellermanns, 2007). Alternatively, actors may create hybrid network positions by emphasizing closure among their direct contacts and substituting their partners’ bridging ties for their own (Baum et al., 2007). These hybrid options, however, focus exclusively on the network level of analysis, which makes unilateral adjustments complicated and time-consuming for an individual actor to make. For example, even if a network actor could assemble a group of people from different social circles, organizations, or backgrounds, they may not have the time or even want to forge a tight-knit group.

In this paper, we propose an alternative hybrid option. Specifically, we examine the network and dyadic levels simultaneously and argue that elements associated with tie strength can act as a substitute for the benefits of network closure. This is because some substantial variation in these dyadic elements is determined by factors other than the surrounding network structure.

**Strong Network-Bridging Ties**

A network-bridging tie is a relationship that spans a structural hole in a network, i.e., it is defined by the network structure that surrounds the tie, and it can be either a strong or weak tie (Burt, 2005) (see Fig. 1). While some prior studies have conceptualized “bridging” ties as ties across a formal organizational boundary (e.g., Tortoriello & Krackhardt, 2010), across areas of expertise (Phelps, 2010; Reagans & McEvily, 2003; Reagans & Zuckerman, 2001; Tiwana, 2008), or across demographic groups (Reagans & Zuckerman, 2001), we focus here on bridging ties in the traditional sense, i.e., as links across the informal network structure to contacts that are not connected to each other (Burt, 1992, 1997a).

[ Insert Figure 1 about here ]

At first glance, a strong bridge seems like an oxymoron. After all, building on balance-theoretic arguments (Heider, 1958; Newcomb, 1961), early work on tie strength concluded that
“except under unlikely conditions, no strong tie is a bridge.” (Granovetter, 1973: 1364, emphasis in original). Only recently has the social network literature acknowledged the possibility of strong network-bridging ties. Burt (2005: 24), for example, defines a bridging tie as “a (strong or weak) relationship for which there is no effective indirect connection through third parties.” Sometimes people whose relationship spans a structural hole simply “hit it off” by either finding things in common other than mutual contacts, such as similar attitudes, values, working style, outside interests, professional background, and so forth, or by recognizing that they are complementary to each other (Dwyer, 2000). These things can forge a strong bond even without the benefit of knowing people in common, i.e., without network closure around the relationship.

Early research on tie strength has established that stronger ties in general lead to greater knowledge exchange. In particular, tie strength increases people’s motivation to be more easily available, treat each other well, and assist each other (Granovetter, 1982; Krackhardt, 1992). Extending those arguments, we propose that tie strength will be especially useful for receiving knowledge from a network-bridging tie because tie strength can act as a substitute for the benefits of network closure. Unlike weak network-bridging ties, which have only the potential to provide access to novel knowledge (Burt, 1992; Granovetter, 1973), strong network-bridging ties make both sides less suspicious of each other and more willing and able to engage in a knowledge transfer (Granovetter 1982, Krackhardt 1992), thereby allowing the knowledge seeker to make fuller use of the opportunity provided by the network-bridging tie. Thus, we would expect that tie strength will enhance the value of a tie that bridges a structural hole, “unlocking” that tie’s potential by making deep, meaningful exchanges between the two actors more likely. Conversely, since network closure already encourages the kind of cooperation and sharing necessary for knowledge exchanges to be useful (Coleman, 1988, 1990), we would expect tie strength to have little or no effect on a tie that is densely embedded in the surrounding network structure.
We believe, however, that this baseline expectation, i.e., that tie strength moderates the value of structural holes, is insufficient without further examining the conceptual underpinnings of what one means by the “strength” of a tie. In particular, the construct of tie strength is actually in many ways an umbrella construct (Hirsch & Levin, 1999) in that it contains multiple elements that may not always act in concert. Indeed, Granovetter (1973: 1361) originally defined tie strength not as a unitary concept but rather as “a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie.” Since then, subsequent scholars have tended to conceptualize it as either emotional closeness (Moran, 2005; Seibert, Kraimer, & Liden, 2001; Yli-Renko, Autio, & Sapien-za, 2001), as interaction frequency (Aral & Van Alstyne, forthcoming; McFadyen & Cannella, 2004; McFadyen, Semadeni, & Cannella, 2009; Reagans & McEvily, 2008; Reagans & Zucker-man, 2001; Tortoriello & Krackhardt, 2010), or as combinations of the two (Cross & Sproull, 2004; Hansen, Mors, & Lovas, 2005; Hansen, Podolny, & Pfeffer, 2001; Lechner, Frankenberger, & Floyd, 2010; Levin & Cross, 2004; Molina-Morales & Martinez-Fernandez, 2009; Morris-son, 2002; Perry-Smith, 2006; Reagans, 2005; Reagans & McEvily, 2003). Still other scholars have conceptualized tie strength as a proxy for trust (Gulati, 1995) and argued that relational trust is the actual dyadic mechanism responsible for these knowledge-transfer benefits (Levin & Cross, 2004). In some instances, these various elements work in parallel—e.g., when two people communicate frequently and feel a close connection (e.g., Reagans & McEvily, 2003)—but this is not necessarily the case for a variety of relationships. In fact, several studies provide empirical evidence suggesting that these different dyadic elements are not unitary (Aral & Van Alstyne, forthcoming; Hansen et al., 2001; Lechner et al., 2010; Wegener, 1991) and may actually operate independently (Ibarra, 1995; Marsden & Campbell, 1984).

Burt’s (1997b) study provides some conceptual insights into differences among these dy-
adic elements. He found that managers sorted relationships on two dimensions of strength—
imintimacy (especially close versus distant) versus activity (frequent versus rare contact), which led
him to conclude that “[m]anagers, like people in the general population, do not distinguish rela-
tions on a single dimension of strong versus weak. They distinguish on orthogonal dimensions of
intimacy and activity” (Burt, 1997b: 363). This finding also resonates with more recent work,
such as Levin et al. (2011), who found that “dormant” ties that had once been close but where
interaction frequency has shrunk to zero in recent years nevertheless retain the benefits of close
ties—thereby suggesting that closeness and interaction frequency are not only conceptually dis-
tinct but can diverge markedly. Similarly, Levin and Cross (2004) demonstrate that a combina-
tion of closeness and interaction frequency is conceptually and empirically distinct from rela-
tional trust, i.e., sometimes people trust that someone will care about them and look after their
interests even if they do not know the other person very well—or even at all (Meyerson, Weick,
& Kramer, 1996).

Moreover, the antecedents and consequences of each of these dyadic elements are differ-
ent. For example, interaction frequency is typically the result of working together, physical prox-
imity, and so forth (Newcomb, 1961). In contrast, relational trust can be the result of interactions,
too, but can also result from similar demographics (Levin, Whitener, & Cross, 2006) or su-
perordinate identity (Kane, 2010), an observed pattern of trustworthy behavior (Whitener, Brodt,
Korsgaard, & Werner, 1998), a corporate culture of cooperation (Abrams, Cross, Lesser, & Le-
vin, 2003), or any number of other factors unrelated to dyadic frequency or closeness.

Thus, to better understand the precise dyadic mechanism that might duplicate the benefits
of network closure and that could therefore enhance the knowledge value of a network-bridging
tie, it is helpful to examine which basic concept—i.e., frequency, closeness, and/or trust—is the
critical element. As Krackhardt (1992: 216) has argued, “[t]his is not simply a question for the
methodologically curious. It is an important part of the theory itself”. Such a more fine-grained approach therefore has the advantage that it allows us to tease apart what is the underlying dyadic mechanism that moderates the knowledge benefits of structural holes.

**High-Frequency Network-Bridging Ties**

Conceptually, there are two main reasons to expect frequent interactions to have a beneficial effect on knowledge transfer. The first is a direct effect of higher interaction frequency, in that it provides more opportunities for communication and more total information flow (Aral & Van Alstyne, forthcoming; Granovetter, 1973). That is, the more conversations that take place along the network-bridging tie, the more likely it might be that each party will share and learn from each other. The second reason is an indirect effect, in that more frequent interactions among individuals may lead to more effective communication through, for example, the development of a common language and relationship-specific heuristics that facilitate cooperation, joint problem solving (Uzzi, 1997), and innovations (Tortoriello & Krackhardt, 2010). These heuristics are particularly important for assimilating idiosyncratic, context-specific, and complex forms of knowledge, which often need multiple opportunities to assimilate (Hansen, 1999).

These benefits may be particularly critical for network-bridging ties, in that such ties often suffer from a lack of shared understanding or framework and thus may require additional interactions before they can become a source of useful knowledge. This reasoning suggests that frequent interactions will allow knowledge seekers to unlock the value of the opportunity provided by the network-bridging tie. In formal terms, we hypothesize a structural holes * interaction frequency moderator effect:

*Hypothesis 1 (H1): All else equal, interaction frequency will enhance the value of a tie that bridges a structural hole, such that the more frequent the interactions for the network-bridging tie, the more useful the knowledge transferred via that tie will be.*
Conceptually, however, the beneficial effects of frequent interactions on knowledge transfer across a bridging tie may be indirect, i.e., it may not be interaction frequency per se that enhances the willingness of source and recipient to engage in a productive exchange, but through another variable. Building on Homans’s (1950) insight that the more frequently people interact with one another the stronger their sentiments of friendship for each other will be, several authors have argued that this increased affection for one another should make contacts more willing to treat one another well and do whatever it takes to make a knowledge exchange succeed (Casciaro & Lobo, 2005, 2008; Krackhardt, 1992; McFadyen & Cannella, 2004). In other words, interaction frequency might sometimes enhance emotional closeness, which may in fact have a more potent impact in enhancing the value of a knowledge exchange via a bridging tie. In light of this possibility, we turn next to the role of emotional closeness.

Close Network-Bridging Ties

Emotional closeness measures the affect (Casciaro & Lobo, 2008; Reagans, 2005) or personal familiarity (Moran, 2005) in a relationship. Krackhardt (1992), in particular, has emphasized the importance of this element by arguing that Granovetter’s (1973) original theory on tie strength draws on balance theory (Heider, 1958; Newcomb, 1961) and that the underlying rationale for balance is psychological. For this reason, “[w]ithout positive affect, there is less motivation to maintain Heiderian balance, to share confidential information or refrain from malfeasance” (Krackhardt, 1992: 219). Several more recent studies have since concurred with this assessment and have suggested emotional intensity (McEvily & Zaheer, 1999) or closeness (Lechner et al., 2010) as the main mechanism behind the benefits of strong ties. In particular, the level of emotional attachment or commitment to the relationship affects the motivation to provide assistance or support (Granovetter, 1982; Reagans & McEvily, 2003), i.e., close contacts are generally more inclined to make the effort to carefully explain, detail, or listen to novel or complex
As noted earlier, what brokerage often lacks is the willingness between knowledge source and knowledge seeker to help each other. This willingness, however, is often what emotional closeness contributes to a relationship; i.e., the motivation for knowledge sources to share their insights, and for knowledge seekers to listen and assimilate the exchanged information. Thus, while this feeling of dyadic closeness may be redundant in an already-dense network, it should be particularly helpful in amplifying the degree of useful knowledge transfer across a network-bridging tie. In formal terms:

Hypothesis 2 (H2): All else equal, emotional closeness will enhance the value of a tie that bridges a structural hole, such that the closer the network-bridging tie, the more useful the knowledge transferred via that tie will be.

**Trusted Network-Bridging Ties**

Lastly, and apart from the dyadic elements of frequency or closeness, it may actually be a feeling of trust that encourages people to share and learn from each other across a network-bridging tie. A trusted tie is a relationship where there is a willingness to be vulnerable (Mayer, Davis, & Schoorman, 1995; Rousseau, Sitkin, Burt, & Camerer, 1998; Whitener et al., 1998), and in the case of relational trust—which is our focus—this willingness is due to a belief that the other party is benevolently concerned for one’s welfare (Mayer et al., 1995; Whitener et al., 1998). Frequency and closeness can each create such trust (Levin & Cross, 2004; Tsai & Ghoshal, 1998), but so can non-relationship factors like an observed pattern of trustworthy behavior (Whitener et al., 1998), a third-party referral, a common background, similar demographics (Levin et al., 2006), a superordinate identity (Kane, 2010), a corporate culture of cooperation (Abrams et al., 2003), subliminal cues (Huang & Murnighan, 2010), or any number of other factors. In fact, the trust literature has identified dozens of “trust builders” (for an overview, see Levin,
2008), and trust has been shown to occur swiftly even among strangers in newly formed groups (Meyerson et al., 1996). Thus, trusted ties can be high- or low-frequency ties and can be close or distant (Levin & Cross, 2004).

Prior research has found that trust acts as a governance mechanism that facilitates knowledge exchange by decreasing competitive and motivational barriers (Krackhardt, 1990, 1992; McEvily, Perrone, & Zaheer, 2003), thereby enhancing the value of such exchanges (Levin & Cross, 2004; Levin et al., 2011; Tsai & Ghoshal, 1998), especially when these exchanges encompass high-quality information or tacit knowledge (Uzzi, 1996). For example, trust allows a knowledge recipient to act upon and use new knowledge, rather than having to expend time and effort verifying its validity (Currall & Judge, 1995; McEvily et al., 2003; Zaheer, McEvily, & Perrone, 1998). Moreover, given the fact that trust is usually reciprocated (Ferrin, Bligh, & Kohles, 2008; Ferrin, Dirks, & Shah, 2006), a trusted tie can also help reduce a knowledge source’s concerns about knowledge appropriation and misuse; thus, actors should be more willing to share sensitive and proprietary details when trust is in place (McEvily et al., 2003; Nahapiet & Ghoshal, 1998; Tsai & Ghoshal, 1998). Trust may therefore make “the difference between a short and possibly guarded hallway conversation about a new idea and active and open brainstorming and tweaking of a new initiative” (Moran, 2005: 1136). Following this line of reasoning, we suggest that, while trust may not provide as much additional benefit in the context of network closure, trust will disproportionately enhance the value of a network-bridging tie. Formally:

*Hypothesis 3 (H3): All else equal, relational trust will enhance the value of a tie that bridges a structural hole, such that the more trusted the network-bridging tie, the more useful the knowledge transferred via that tie will be.*
METHODS

Sample and Procedures

To test our hypotheses, we approached a large U.S. engineering firm which had a reputation for world-class engineering capabilities and which was one of the top three global producers in its primary product category. The firm’s senior engineering manager agreed to have a web survey distributed to all 303 members of his staff who were believed to have worked on a particular project. This project required numerous areas of engineering expertise, ran for more than five years, and spanned research and development, prototype design and testing, and manufacturing. Individual participation in the survey was voluntary and strictly confidential (though not anonymous). We pre-tested and revised our survey based on feedback from 15 engineers working at a firm providing engineering services on a contract basis to the target firm. Some of these engineers were former employees of the target firm. We then emailed a password and link to the web-based survey to the 303 people at the target firm, with non-respondents receiving at least three email reminders over a two-month period. Of the 303, a total of 34 indicated they were ineligible to participate, e.g., they had not worked on the focal project. Of the remaining 269, we received data from 62 (response rate = 23%). While this may seem low, it is actually fairly typical for social network-related surveys of this length (e.g., Seibert et al., 2001, reported a response rate of 28%). More importantly, whereas response rates are of substantial concern for bounded network studies, where the accuracy of network-level measures depends on having data from most, if not all, network members, our focus is on respondents’ egocentric networks. These, by definition, do not require information on the network structure beyond a respondent’s direct ties.

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2 We suspect that more employees than just these 34 who wrote back were ineligible to participate—a fact which would have increased our stated response rate (by lowering the denominator of eligible employees)—but we were unable to confirm this one way or the other with the company. It is doubtful that any ineligible employee would have completed the survey, given the survey instructions’ repeated emphasis on the focal project.
(Burt, 1992; Wasserman & Faust, 1994), and therefore only need to be representative of—and not cover in its entirety—the overall network structure.

We use hierarchical linear modeling (HLM) for our statistical analyses, allowing us to tease apart the impact of respondents from the effects of their dyadic relationships. HLM automatically deletes any observations with missing data for even a single survey item at the respondent level, a restriction which further reduced the usable sample to a total of 408 dyadic knowledge-seeking relationships, assessed by 41 engineers. Given our focus on dyadic ties as the unit of analysis, however, we were less concerned about the number of respondents than the number of ties. This is consistent with other social network studies that typically study a small number of network actors in connection with knowledge transfer (e.g., Hansen, 1999; Tsai, 2002; Tsai & Ghoshal, 1998).

To see if there was a systematic difference between respondents and non-respondents, we compared their gender, which was the only demographic variable made available to us for both groups, and found no significant difference ($t = 0.17, p = .862$). In addition, within the group of 62 initial respondents, we detected no significant differences between those who provided partial versus full data, e.g., in terms of gender ($t = 0.23, p = .820$), how long they had been working on the focal project ($t = 0.71, p = .484$), how much of their time the project took ($t = 1.03, p = .310$), and how many people they had consulted ($t = 0.19, p = .847$).

Demographically, respondents were 87.8% male, an average of 44.8 years old, and had an average tenure of 5.1 years in their current job and 17.2 years at the company. All respondents had attended at least some college, and nearly two thirds (64%) had a graduate degree. On average, respondents had worked on 11.4 previous projects in the same technical area as their involvement in the focal project, which consumed about half (52.5%) of their time. Average project involvement was 29.7 months.
At the start of the survey, we asked respondents, “Within the [focal project] effort, think of a major task or project that holds significance for your career.” We then told respondents to “answer the rest of the questions as they pertain specifically to your involvement with the selected project or task, a part of the larger [focal project] effort.” By focusing on a specific task or project, we aimed to ground the responses in a more concrete set of experiences (Levin & Cross, 2004; Levin et al., 2011), thereby reducing any recall or other biases (Marsden, 1990, 1993).

Using standard egocentric network survey techniques (Burt, 1992; Wasserman & Faust, 1994), we created respondents’ egocentric advice networks by asking them to list by name—or by a more anonymous shorthand, such as initials—up to 20 people either inside or outside the firm whom they had consulted as part of their work on their task or project; i.e., people “who may have tried to provide: information, advice on a technical issue, or advice on an organizational issue like budgeting, deliverables, etc.” To reduce selection bias, respondents were asked to include all sources they consulted, “whether or not they were useful in this particular instance.” We then asked a series of questions about all of these knowledge sources, including how well they knew one another. On average, our respondents consulted with 10.0 people, 85.3% of whom were in the surveyed company and 74.4% of whom were working on the same project.

**Measures**

**Outcome (dependent) variables.** While there are a number of typologies of knowledge, such as knowledge tacitness or complexity (Zander & Kogut, 1995), our focus here is on the useful, substantive, micro-level content that gets exchanged between knowledge source and recipient in an organizational setting. To that end, we draw on the literature that examines the micro foundations of organizational learning and knowledge transfer, which conceptualizes this phenomenon as a process of solving problems, or more precisely, as the matching of problems with solutions (Cyert & March, 1963; Greve, 2003). Taking this view, we suggest that there are at
least two types of useful, substantive content that knowledge recipients seeking help on a problem can receive: either solutions to their problem or a new way of looking at their problem (Cross & Sproull, 2004).

Thus, for solutions and problem reformulation, we obtained the survey instrument used by Cross and Sproull (2004) and used nearly identical wording (see Appendix for all of the items). One minor difference is that, whereas they asked about the impact on “completing” one’s work, we felt that the usefulness of knowledge can extend beyond task completion, and so we asked how positively or negatively each type of useful knowledge from each knowledge source contributed to the respondent’s project performance. While other types of actionable knowledge, such as referrals, can be useful as well (Cross & Sproull, 2004), these lack the substantive content provided by solutions and problem reformulation. To test our hypotheses, we undertook two separate analyses to examine the role of network-bridging ties on the transfer of these two types of useful knowledge, with each analysis designed to validate the other.

**Predictor (independent) variables.** Using Burt’s (1992) approach and language, we measured **closeness** on a 3-point scale (0 = distant, 1 = in-between, 2 = especially close, reverse coded as 2, 1, 0). To compute the degree to which a given tie spanned structural holes—i.e., it was a network-bridging tie—we generated an adjacency matrix for each respondent’s egocentric advice network, using the valued data on closeness. Following Burt (1992), we analyzed the egocentric network data using UCINET 6.135 (Borgatti, Everett, & Freeman, 2002) to calculate **structural holes**, defined as one minus the value of constraint \( c_{ij} \) posed by an individual alter \( j \):

\[
c_{ij} = \left( p_{ij} + \sum_{q \neq i, j} p_{iq} p_{qj} \right)^2, \quad \text{for } q \neq i, j,
\]

where \( p_{ij} \) is the proportion of \( i \)’s relations invested in \( j \), \( p_{iq} \) is the proportion of \( i \)’s relations invested in \( q \), and \( p_{qj} \) is the proportion of \( q \)’s relations invested in \( j \). One minus constraint \((1 - c_{ij})\) is
thus the lack of constraint—or, the extent of structural holes—present around $i$’s tie to contact $j$.

For relational trust, also known as perceived benevolence (Mayer & Davis, 1999; Mayer et al., 1995), we used a measure from Mayer and Davis (1999) of the respondent’s perception that the knowledge source cared about the respondent’s welfare. We focused on this type of trust, because it “is typically a function of a specific relationship” (Levin et al., 2006: 1164)—which is our interest for H3—whereas other forms of trust, such as perceptions of an individual’s ability, “are mainly characteristics of the individual” (Levin et al., 2006: 1164). For interaction frequency, we used the same scale as Levin and Cross (2004), with a focus here on communication since the start of the focal project. Before creating the interaction terms to test for the moderation effects, we mean-centered all independent variables.

**Control variables.** To rule out alternative explanations, we controlled for a number of factors that might confound our results. Because demographic similarity (i.e., homophily) is often correlated with perceptions of trustworthiness, helpfulness, and performance (Ferrin et al., 2006; Ibarra, 1993; Shore, Cleveland, & Goldberg, 2003; Tsui & O’Reilly, 1989), we included same age (+/- 5 years), same gender, and same race/ethnicity as control variables in our analysis. To account for respondents selecting relationships based on happenstance or convenience, we also controlled for physical proximity between the respondent and knowledge source, using an item from Levin and Cross (2004), as well as for communication in person, i.e., as mostly face-to-face versus mostly via other communication modes like phone or email. Additionally, we included the perceived competence of the knowledge source (as perceived by the respondent) using an item adapted from one of Butler’s (1991) competence measures. To control for the cognitive dimension of the relationship, we used a measure—adapted from items used by Levin et al. (2006) and Tsai and Ghoshal (1998)—for the extent to which respondents felt they had a shared perspective with each source. Finally, we controlled for relationship length, as this may affect
both the quality of the relationship and of the knowledge being transferred. We measured relationship length as the logarithm of the number of months since the respondent had first met each knowledge source (Currall & Judge, 1995; Levin et al., 2006).

**Reliability Issues**

To reduce survey length and accommodate our respondents’ time constraints, we relied on single-item measures for our variables. Although single-item measures are not ideal, they are typical for network research (e.g., Borgatti & Cross, 2003; Seibert et al., 2001). A review by Marsden (1990) suggests they are largely reliable when the appropriate procedures are followed to help respondents accurately report on their network contacts. Accordingly, each of our items was as specific as possible—including a number of examples—to enhance recall. We also asked respondents to assess typical interactions, an approach which previous research has found to be highly accurate (Freeman, Romney, & Freeman, 1987).

Concerning the accuracy of recall for respondents’ indirect ties, McEvily and Zaheer (1999) found that, in their study, almost three-quarters of the time, a respondent’s assessment of the tie between a pair of his or her contacts corresponded with both contacts’ report of the tie between themselves; and 86% of the time, a respondent’s report of the tie between a pair of contacts was in agreement with at least one of those contacts.

A related concern is that all of our data come from the knowledge recipients; i.e., there is a potential for common methods bias. In designing our study, we considered using other data sources for measuring useful knowledge, such as project outcomes, supervisor ratings, or the perceptions of knowledge sources, but we concluded that these data sources would be either too far removed, uninformed, or biased to be of much use. We assumed that third parties, such as supervisors, are rarely in a position to know the details of a knowledge transfer, let alone its usefulness. Thus, given our focus on knowledge recipients’ definitions of value, we followed previ-
ous prescriptions “that—at the dyadic level of analysis—a knowledge seeker is the best, perhaps the only, judge of the usefulness of knowledge received from a particular source” (Levin & Cross, 2004: 1482, emphasis in original).

In testing for any “common methods variance” that might result from our approach, we were reassured, first, by Harman’s one-factor test. Specifically, when we conducted a principal components factor analysis of all the interval-scale variables used in each of our regression models, there were always two or three factors—never just one—with eigenvalues higher than 1.0. Moreover, the largest eigenvalue never accounted for more than 33.8% of the total variance, well below the 50% rule-of-thumb cut-off (Podsakoff & Organ, 1986). Second, the web-based nature of our survey instrument made it more difficult for respondents to use previous answers to fill in retrieval gaps (because each question had its own web page), a feature which helps reduce common methods bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Third, our structural holes measure is fairly concrete (and is computed in ways that would not be obvious to respondents) and hence should be considerably less vulnerable to the possibility that respondents unthinkingly rated each person as either always high or low across the board (Doty & Glick, 1998). Fourth, moderator effects, as in our study, are less vulnerable to common methods bias, as noted by Brockner, Siegel, Daly, Tyler, and Martin (1997) and others, “because it shows that respondents did not unthinkingly rate all items as either high or low” (Levin & Cross, 2004: 1482). Indeed, based on a series of Monte Carlo simulations, Evans (1985) concluded that the likelihood of obtaining significant moderator effects is reduced, not enhanced, to the extent that a method effect is present. Thus, we conclude that any common methods variance resulting from our approach appears to be minor and unlikely to affect our results.

**Analysis Techniques**

We used hierarchical linear modeling (HLM) to test our hypotheses (Bryk & Rauden-
bush, 1992). HLM is ideally suited for nested data—in our case, knowledge-seeking, dyadic relationships (“Level 1”) nested within respondents (“Level 2”) (Cross & Sproull, 2004; van Duijn, van Busschbach, & Snijders, 1999)—as it does not rest on the assumption of independent observations, as traditional ordinary least squares (OLS) regression does (Hofmann, Griffin, & Gavin, 2000). In contrast to OLS, HLM allows the researcher to tease apart the variance explained by characteristics of the individual respondents from the variance explained by each dyadic tie by formally representing each level of analysis with its own sub-model (cf., Hofmann, 1997).

**RESULTS**

Supporting our argument that interaction frequency, closeness, and relational trust are conceptually distinct, these three dyadic elements were only moderately correlated (Table 1, \( r’s = .29 \) to \( .37 \)), suggesting that respondents were able to distinguish among these three elements. Interestingly, 46% of the ties in our sample were above average for structural holes and also for interaction frequency, i.e., 46% were higher-frequency network-bridging ties; 42% were more-trusted network-bridging ties; and 6% were “especially close” network-bridging ties and another 57% “in-between” (in terms of closeness) network-bridging ties. This suggests that many bridging ties are not necessarily very low in interaction frequency, relational trust, or closeness, and thus the kinds of bridges that we are interested in investigating are not so rare after all.

[ Insert Tables 1-3 and Figures 2a and 2b about here ]

Not explicitly hypothesized, but in line with prior research that has found ambiguous results with respect to tie strength (see our literature review above), the main effects of interaction frequency, emotional closeness, and relational trust are ambiguous across our two dependent variables, with no consistently significant main effect for any of the three (Table 2, Model 1 and Table 3, Model 6). Turning next to our hypotheses, when our outcome variable is the receipt of useful knowledge in the form of solutions (Table 1), we find no support for H1: the structural
holes * frequency interaction term is not statistically significant when it is the only moderator effect included (Model 2, \( p = .520 \)), and it is marginally significant but negative, i.e., the opposite of what we hypothesized, when all three interaction terms are included (Model 5, \( p = .063 \)).

As shown in Table 3, H1 is also not supported for the receipt of useful knowledge in the form of problem reformulation: the relevant interaction term is not statistically significant when it is the only moderator effect included (Model 7, \( p = .135 \)), and it is statistically significant but negative when all three interaction terms are included (Model 10, \( p = .011 \)). Thus, all else equal, not only is H1 not supported, but the opposite seems to be the case, i.e., the more frequent a tie’s communication is, the less impact structural holes have on the receipt of useful problem-reformulation knowledge for that tie.

H2 is partially supported in that the structural holes * closeness interaction term in Table 2 is statistically significant when it is the only moderator effect included for the outcome variable of receipt of useful solutions (Model 3, \( p = .034 \)). However, once we take into account the other two moderator effects, the structural holes * closeness interaction term becomes non-significant (Model 5, \( p = .635 \)). Further, in Table 3, when the outcome variable is the receipt of useful problem-reformulation knowledge, H2 is also not supported, i.e., the structural holes * closeness interaction term is non-significant in both Model 8 (\( p = .269 \)) and Model 10 (\( p = .917 \)). On balance, then, H2 receives at most only partial support.

H3 is fully supported. In Table 2 the structural holes * trust interaction term is statistically significant both by itself (Model 4, \( p = .004 \)) and when the other moderator effects are included (Model 5, \( p = .035 \)). Similarly in Table 3, the relevant interaction term is statistically significant both by itself (Model 9, \( p = .014 \)) and when the other moderator effects are included (Model 10, \( p = .011 \)). In other words, the more trusted a tie is, the greater the impact of structural holes on the receipt of useful knowledge, both for solutions and problem reformulation.
To illustrate this moderator effect visually, we draw a figure of two simple slopes (see Figs. 2a and 2b): the effect of structural holes on receipt of useful knowledge when relational trust is a standard deviation above the mean and when it is a standard deviation below the mean. As these figures suggest, when trust is high, structural holes lead to the receipt of more useful knowledge, but when trust is low, we find the opposite effect; namely, it is network closure (i.e., fewer structural holes) that is more valuable when trust is low.

**Robustness Checks**

Recent literature on closure and brokerage has focused on ties that serve as a bridge across formal organizational boundaries (Burt, 2005; Reagans & McEvily, 2003; Tortoriello & Krackhardt, 2010). We therefore analyzed whether there were any differences in our sample between network-bridging ties to colleagues on the same work task/project and those to colleagues outside the task/project. In particular, we wanted to know if the role of relational trust in enhancing the value of network brokerage applies to network-bridging ties whether the other person is working on the same task/project or not. When we controlled for ties bridging project groups, however, all results remained the same with the exception of structural holes * frequency, which went from marginally negative (Model 5, \( p = .063 \)) to non-significant (\( p = .151 \)) for solutions. Based on these results, we conclude that relational trust enhances the value of network-bridging ties, regardless of whether these ties connect colleagues within or outside a work task/project. Thus, it would appear that our findings—which combine dyadic and egocentric network structure—occur over and above the impact of more formal social structures.

We also checked for multicollinearity in all our models, to rule this out as an alternative explanation. Although there is no direct diagnostic test for multicollinearity in HLM, we tested for this potential problem using OLS regression in the SPSS statistical package. The result was that all variance inflation factors (VIFs) were below 2.8, well below the standard cut-off of 10.
Finally, to assess the robustness of our findings further, we also tested eight additional control variables at the respondent (i.e., “Level 2”) level of analysis: (1) the number of previous projects in the same technical area that the respondent was involved in (a proxy for the respondent’s level of experience); (2) percentage of a respondent’s work day spent on the task/project; (3) education (with dummy variables corresponding to some college, bachelor’s, master’s, and doctorate); (4) tenure at the company; (5) tenure in the current job; (6) gender; (7) age; and (8) network density (i.e., the number of ties among the respondent’s contacts, divided by the maximum possible number of such ties). The latter variable was included to take into account any effects of information volume (i.e., the quantity of information available to the knowledge seeker) in our results (Koka & Prescott, 2002). When we added these eight controls (not shown due to space considerations), our hypothesized results remained the same with respect to both directionality and significance, with the exception of the structural holes * closeness interaction, which went from fully (in Model 3, \( p = .034 \)) to marginally significant (\( p = .052 \)), and the structural holes * frequency interaction, which increased in significance from \( p = .063 \) (Model 5) and \( p = .011 \) (Model 10) to \( p = .028 \) and \( p = .004 \), respectively. Thus, our results were robust to several alternative explanations, with statistically significant results over and above both dyadic- and respondent-level controls.

**DISCUSSION**

Analyzing 408 advice-seeking relationships in a large U.S. engineering firm provides strong empirical support for our argument that tie strength enhances the value of network-bridging relationships. Our results further shed light on the mechanism behind the benefits of strong network-bridging ties. That is, we found that it is relational trust, as predicted by H3, that enhances the value of network-bridging ties for the receipt of useful knowledge, even controlling for other possible dyadic mechanisms, such as interaction frequency (H1) or emotional closeness.
(H2), both of which did not consistently or significantly enhance the value of network-bridging ties. Interestingly, for both dependent variables tested, we found that when a particular tie’s relational trust was low, then our respondents benefitted from network closure, i.e., from having densely interconnected contacts. Our results thus provide support for our argument that relational trust at the dyadic level and structural trust (i.e., closure) at the network level may act as substitutes; both allow network actors to reap the benefits of being embedded in social relationships.

One implication of our results is an indication of when having a tie that spans a structural hole is more versus less beneficial for obtaining useful knowledge. Specifically, such a network-bridging tie is especially valuable when it is also a trusted tie. However, when there is little trust, one appears to be better off having fewer structural holes around the tie, i.e., having more network closure. A non-bridging tie might transfer knowledge even without high relational trust between the two parties, e.g., because of the feeling of obligation (or fear of negative consequences) due to the surrounding mutual ties. A network-bridging tie, however, might do so only when the two parties care about each other personally. Thus, another way of looking at our results is that relational trust has a bigger impact for network-bridging ties than for non-bridging ties, because trust can be partially substituted by obligation (or fear) in the case of non-bridging ties but there is no substitute for trust when it comes to network-bridging ties.

One potential drawback to using trust as a substitute for network closure is that closure—unlike relational trust alone—is more likely to create cooperative norms that are enforced by third parties (Granovetter, 1992). For example, if a potential knowledge source refuses to help a knowledge seeker, news of this would likely spread within a tight-knit group and could lead to the source’s ostracism, thereby limiting the source’s own ability to receive future support from fellow group members (Reagans & McEvily, 2003). Such third-party monitoring and reputational effects might also reduce trust violations within the group, such as stealing someone else’s
ideas. With a trusted network-bridging tie, however, knowledge seekers do not have such recourse, since the two sides have few or no third parties in common. Nevertheless, even without this network-based constraint, relational trust (i.e., a confidence that the other person cares about you) is likely to allay most fears of the potential for uncooperative or untrustworthy behavior. Other factors would likely help as well, such as appeals to a superordinate (e.g., companywide) identity (Kane, 2010) or, if it exists, to a collaborative corporate culture (Abrams et al., 2003) or someone with hierarchical or oversight authority. Thus, we would argue that relational trust at the dyadic level as well as other organization-level factors make the threat of third-party interventions by members of a tight-knit group, which network closure can provide, less necessary.

Our findings for trusted network-bridging ties are, in some sense, an extension of earlier work on the benefits of trusted weak ties (Levin & Cross, 2004), i.e., of knowledge-exchange partners who do not know each other well but who nonetheless trust each other. Levin and Cross (2004), however, do not account for network structure, relying solely on tie strength as a proxy for structure. They also follow a somewhat different logic. Specifically, they suggest that tie strength and trust can be seen independently, where high trust gives a relational benefit and weak ties, a structural benefit, but they did not find a moderator effect between these two factors. In our study, we do find a moderator effect such that high trust seems to enable actors to unleash and reap the benefits of bridging a structural hole. Thus, our results address “the trust needed to realize the value of bridging a structural hole” (Burt, 2005: 97).

More broadly, by examining dyadic ties, our study follows the calls of Rowley, Behrens, and Krackhardt (2000), Moran (2005), and others for more attention in the social capital literature to the actual tie between two actors, i.e., to the “line” that connects two nodes in a social network diagram. In contrast to prior work such as Moran’s (2005), however, we present empirical evidence not just for the independent effects of structural and relational social capital, but for
how these two effects *interrelate*. In particular, our study extends recent studies of closure and brokerage, which have focused on ties that serve as a bridge across formal organizational boundaries (Burt, 2005; Reagans & McEvily, 2003; Tortoriello & Krackhardt, 2010). A robustness test described above showed that our findings—which combine dyadic and egocentric network structure—occur over and above the impact of more formal social structures. Based on these results, we conclude that relational trust enhances the value of network-bridging ties, regardless of whether these ties connect colleagues within or outside a work task/project.

Our study also extends recent work by McFadyen, Semadeni, and Cannella (2009), who find that the *average* interaction frequency of an individual’s portfolio of ties can enhance the value of a network with low density. Extrapolating from our findings at the dyadic level to an individual’s portfolio of ties, frequent interaction, by definition, constitutes substantially more maintenance than less-frequented ties (Granovetter, 1973; Hansen, 1999; McFadyen & Cannella, 2004). Actors with high-frequency ties are thus likely to be constrained in their ability to maintain a large number of strong network-bridging ties. This is consistent with our finding that increased interaction frequency may actually diminish the value of a network-bridging tie. On the other hand, we find that relational trust enhances the value of network bridges. Moreover, unlike interaction frequency, many trust-building behaviors—such as being consistent, discreet, open, fair, receptive, warm and engaging, and so forth (Abrams et al., 2003; Levin, 2008; Levin et al., 2006; Whitener et al., 1998)—are not necessarily time-consuming, so building trust directly offers another option for practitioners interested in enhancing the value of network brokerage.

Somewhat surprisingly, interaction frequency not only did not enhance, but in some cases significantly diminished the value of network-bridging ties. One likely reason for this effect is that frequent interactions can sometimes lead to increasingly redundant knowledge, i.e., to hearing the same things over and over again. Thus, repeated interactions can lead to a congruence of
knowledge stocks between source and recipient (Coleman, 1988), eventually diminishing the marginal returns to any additional interaction. In line with this argument, McFadyen and Canella (2004) found a curvilinear relationship between the number of interactions between scientists and the amount of knowledge created, where too much interaction was counter-productive. This point is echoed in Aral and van Alstyne (forthcoming), who found that information advantages to brokerage depend on whether or not the knowledge stock of alters refreshes enough over time to justify updating; otherwise, more frequent interaction simply leads to receiving the same information again and again. Moreover, this negative effect of interaction frequency should be particularly salient for advice that is dependent on generating novel ideas and insight, such as problem reformulation, which, indeed, is reflected in our results (Model 10 versus Model 5).

Emotional closeness did not have much, if any, impact in enhancing the value of network-bridging ties. While feeling close to someone may sometimes be helpful in unlocking a network-bridging tie’s potential, it does not appear to be the critical element. Rather, there are many different scenarios and other types of relationships besides closeness that can encourage a willingness to engage in a productive knowledge exchange. We would argue that what these alternative scenarios and relationships have in common is relational trust; and it is trust—even without much emotional closeness—that can help ensure that a bridging tie provides value. Thus, our results point to relational trust as the key dyadic mechanism for enhancing brokerage.

Compared to network-level approaches to the closure-brokerage tension offered by Burt (2005) and others, our approach—i.e., trusted network-bridging ties—may be the easiest for actors to implement, as it does not require much investment in ongoing maintenance (e.g., as with closeness and frequency) or any additional actions by third parties (e.g., it does not require closure to form around a bridging tie). From a strategic standpoint, we also suspect that trusted network-bridging ties can be cultivated, just as trust in general can be cultivated (Abrams et al.,
2003), making such ties less rare but just as valuable.

Our findings can also shed some light on ambiguous prior results for tie strength, e.g., some studies have reported an overall advantage for stronger relationships (Aral & Van Alstyne, forthcoming; Ghoshal, Korine, & Szulanski, 1994; Hansen et al., 2001; Krackhardt, 1992; Molina-Morales & Martinez-Fernandez, 2009; Reagans & McEvily, 2003, 2008; Seibert et al., 2001; Tortoriello & Krackhardt, 2010); others, for weaker relationships (Constant, Sproull, & Kiesler, 1996; Granovetter, 1973, 1982; Perry-Smith, 2006; Yli-Renko et al., 2001); and still others, contingent effects (Cross & Sproull, 2004; Hansen, 1999; Lechner et al., 2010; Levin & Cross, 2004; McFadyen & Cannella, 2004; McFadyen et al., 2009; Moran, 2005; Morrison, 2002). Our distinctive results for interaction frequency, emotional closeness, and relational trust, however, suggests that the plethora of conceptual and measurement approaches employed by these prior studies may have contributed to these ambiguous empirical results. Authors might therefore carefully select a measurement approach that is congruent with the theoretical logic of their hypotheses, or ideally include and compare several measurement approaches to disentangle the unique impact of these dyadic characteristics on knowledge and performance outcomes.

Lastly, all studies have limitations, and ours is no exception. One limitation of our study is that we measured structural holes using egocentric, not bounded, network data. As a result, it is possible that what looks like a network-bridging tie in our sample is in fact linked indirectly to the respondent’s other contacts via people not in the respondent’s egocentric network. Though much of the prior research on structural holes relies on egocentric network data (e.g., Burt, 1992)—supported by evidence that brokerage benefits are concentrated mainly in the immediate network around a person (Burt, 2007)—future researchers may want to examine the issue of trusted network-bridging ties in a bounded network as well.

Our study also focused on bridging in a traditional, network structural sense (Burt, 1992),
thereby neglecting bridges across other types of social domains. Future research could thus apply our idea of trusted bridging ties to, for example, obtaining novel knowledge from different organization divisions, functions, hierarchical levels, or domains of expertise (Phelps, 2010; Reagans & McEvily, 2003; Reagans & Zuckerman, 2001; Tiwana, 2008; Tortoriello & Krackhardt, 2010). Moreover, our results may apply to firms as well, since trust has been shown to operate not just between individuals but also between organizations (Zaheer et al., 1998). For instance, firms are more likely to cite the patent of a geographically or technologically distant firm, i.e., obtain useful knowledge from that firm, if they have an alliance with or have recently hired an inventor from that other firm (Rosenkopf & Almeida, 2003). Though not measured directly, as in our study, we suspect that relational trust may be one of the mechanisms underlying these useful “bridges to distant contexts” (Rosenkopf & Almeida, 2003: 751). Future research may uncover other examples of trusted bridging ties among firms as well.

CONCLUSION

In sum, our study provides empirical support for the value of strong network-bridging ties: whereas a network-bridging tie provides access to novel and non-redundant knowledge, a strong tie—or, more precisely, for our purposes, a tie with high levels of relational trust—enables network actors to realize the potential of this knowledge. By focusing on the key social capital dimensions of structural holes and tie strength—conceptualized at the intersection of the network and dyadic levels of analysis—we not only suggest an additional approach to the network brokerage-closure dilemma, but we also offer a systematic way to understand how and why interpersonal relationships can enhance the transfer of useful knowledge.
REFERENCES


FIGURE 1

Hypothetical Egocentric Networks

Figure 1a

Figure 1b
FIGURE 2a
Moderator Effect for Receipt of Useful Knowledge: Solutions

FIGURE 2b
Moderator Effect for Receipt of Useful Knowledge: Problem Reformulation

Note: Based on output from Table 2’s Model 4 (for Solutions) and Table 3’s Model 9 (for Problem Reformulation).
### TABLE 1
Means, Standard Deviations, and Correlations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>S.D.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
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<tr>
<td>1. Solutions</td>
<td>5.82</td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Problem reformulation</td>
<td>5.37</td>
<td>1.29</td>
<td>.67**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Same age</td>
<td>0.39</td>
<td>0.49</td>
<td>.10</td>
<td>.08</td>
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<td>4. Same gender</td>
<td>0.85</td>
<td>0.36</td>
<td>-.07</td>
<td>-.04</td>
<td>.01</td>
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<td></td>
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<tr>
<td>5. Same race/ethnicity</td>
<td>0.86</td>
<td>0.35</td>
<td>.13*</td>
<td>.11*</td>
<td>-.01</td>
<td>-.02</td>
<td></td>
</tr>
<tr>
<td>6. Physical proximity</td>
<td>4.15</td>
<td>1.90</td>
<td>.25**</td>
<td>.25**</td>
<td>.10</td>
<td>.01</td>
<td>-.13*</td>
</tr>
<tr>
<td>7. Perceived competence</td>
<td>6.10</td>
<td>1.37</td>
<td>.53**</td>
<td>.46**</td>
<td>.07</td>
<td>.05</td>
<td>.12*</td>
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<tr>
<td>8. Communication in person</td>
<td>0.72</td>
<td>0.45</td>
<td>.30**</td>
<td>.23**</td>
<td>.10</td>
<td>.01</td>
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<td>9. Relationship length</td>
<td>1.61</td>
<td>0.47</td>
<td>-.06</td>
<td>.08</td>
<td>.00</td>
<td>-.03</td>
<td>.01</td>
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<td>10. Shared perspective</td>
<td>5.23</td>
<td>1.27</td>
<td>.60**</td>
<td>.58**</td>
<td>.08</td>
<td>-.09</td>
<td>.27**</td>
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<td>11. Structural holes</td>
<td>0.95</td>
<td>0.06</td>
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<td>-.12*</td>
<td>.03</td>
<td>.24**</td>
<td>.03</td>
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<td>12. Interaction frequency</td>
<td>4.80</td>
<td>1.87</td>
<td>.29**</td>
<td>.24**</td>
<td>.03</td>
<td>.05</td>
<td>.01</td>
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<td>13. Closeness</td>
<td>1.98</td>
<td>0.49</td>
<td>.34**</td>
<td>.29**</td>
<td>.12*</td>
<td>-.12*</td>
<td>-.02</td>
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<tr>
<td>14. Relational trust</td>
<td>4.71</td>
<td>1.29</td>
<td>.42**</td>
<td>.48**</td>
<td>-.01</td>
<td>.01</td>
<td>.05</td>
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<tr>
<td>15. Structural holes * frequency</td>
<td>-0.01</td>
<td>0.09</td>
<td>.02</td>
<td>-.08</td>
<td>-.01</td>
<td>-.07</td>
<td>-.05</td>
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<td>-0.01</td>
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<td>.01</td>
<td>-.01</td>
<td>-.02</td>
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<td>.07</td>
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<td>0.08</td>
<td>.10</td>
<td>.06</td>
<td>.01</td>
<td>.01</td>
<td>.08</td>
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<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<tr>
<td>6. Physical proximity</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Perceived competence</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Communication in person</td>
<td>.59**</td>
<td>.20**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Relationship length</td>
<td>.10</td>
<td>.02</td>
<td>.00</td>
<td></td>
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</tr>
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<td>.33**</td>
<td>.17**</td>
<td>.06</td>
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<tr>
<td>11. Structural holes</td>
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<td>-.01</td>
<td>-.11*</td>
<td>-.22**</td>
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<td>.14**</td>
<td>.26**</td>
<td>.01</td>
<td>.28**</td>
<td>-.07</td>
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<tr>
<td>13. Closeness</td>
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<td>.20**</td>
<td>.24**</td>
<td>.25**</td>
<td>.40**</td>
<td>-.25**</td>
<td>.29**</td>
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<tr>
<td>14. Relational trust</td>
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<td>.30**</td>
<td>.25**</td>
<td>.04</td>
<td>.46**</td>
<td>-.11*</td>
<td>.30**</td>
</tr>
<tr>
<td>15. Structural holes * frequency</td>
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<td>.01</td>
<td>-.02</td>
<td>.00</td>
<td>.08</td>
<td>.03</td>
<td>.16**</td>
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<tr>
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<td>.05</td>
<td>-.03</td>
<td>-.01</td>
<td>.02</td>
<td>.59**</td>
<td>.02</td>
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<td>17. Structural holes * trust</td>
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<td>-.12*</td>
<td>-.05</td>
<td>.06</td>
<td>.26**</td>
<td>.00</td>
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<table>
<thead>
<tr>
<th>Variable</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
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<tbody>
<tr>
<td>13. Closeness</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>14. Relational trust</td>
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<tr>
<td>15. Structural holes * frequency</td>
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<td></td>
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<td>16. Structural holes * closeness</td>
<td>-.15**</td>
<td>-.07</td>
<td>.27**</td>
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</tr>
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<td>17. Structural holes * trust</td>
<td>-.10*</td>
<td>-.06</td>
<td>.29**</td>
<td>.60**</td>
</tr>
</tbody>
</table>

*Note: For variable 1, \( N = 359 \); variable 2, \( N = 347 \); variables 3-17, \( N = 376 \). Two-tailed tests.  
* \( p < .05 \); ** \( p < .01 \)
TABLE 2  
HLM Regression Results for Receipt of Useful Knowledge: Solutions

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same age</td>
<td>0.06 (0.08)</td>
<td>0.06 (0.08)</td>
<td>0.06 (0.08)</td>
<td>0.06 (0.08)</td>
<td>0.07 (0.08)</td>
</tr>
<tr>
<td>Same gender</td>
<td>0.20 (0.18)</td>
<td>0.20 (0.18)</td>
<td>0.21 (0.18)</td>
<td>0.20 (0.19)</td>
<td>0.19 (0.19)</td>
</tr>
<tr>
<td>Same race/ethnicity</td>
<td>-0.07 (0.19)</td>
<td>-0.07 (0.19)</td>
<td>-0.08 (0.19)</td>
<td>-0.07 (0.18)</td>
<td>-0.09 (0.17)</td>
</tr>
<tr>
<td>Physical proximity</td>
<td>0.02 (0.04)</td>
<td>0.03 (0.04)</td>
<td>0.02 (0.04)</td>
<td>0.02 (0.04)</td>
<td>0.03 (0.04)</td>
</tr>
<tr>
<td>Perceived competence</td>
<td>0.43*** (0.11)</td>
<td>0.43*** (0.11)</td>
<td>0.43*** (0.11)</td>
<td>0.43*** (0.11)</td>
<td>0.43*** (0.11)</td>
</tr>
<tr>
<td>Communication in person</td>
<td>0.23† (0.14)</td>
<td>0.23 (0.14)</td>
<td>0.24† (0.14)</td>
<td>0.25† (0.14)</td>
<td>0.24† (0.13)</td>
</tr>
<tr>
<td>Relationship length</td>
<td>-0.28* (0.14)</td>
<td>-0.28* (0.13)</td>
<td>-0.30* (0.14)</td>
<td>-0.30* (0.14)</td>
<td>-0.32* (0.14)</td>
</tr>
<tr>
<td>Shared perspective</td>
<td>0.30** (0.09)</td>
<td>0.31*** (0.09)</td>
<td>0.29** (0.09)</td>
<td>0.30*** (0.09)</td>
<td>0.30*** (0.09)</td>
</tr>
<tr>
<td>Structural holes</td>
<td>-0.08 (1.16)</td>
<td>0.00 (1.13)</td>
<td>-1.91 (1.57)</td>
<td>-1.18 (1.19)</td>
<td>-1.70 (1.54)</td>
</tr>
<tr>
<td>Interaction frequency</td>
<td>0.06† (0.04)</td>
<td>0.07† (0.03)</td>
<td>0.07† (0.04)</td>
<td>0.06† (0.04)</td>
<td>0.07* (0.03)</td>
</tr>
<tr>
<td>Closeness</td>
<td>0.37* (0.16)</td>
<td>0.37* (0.16)</td>
<td>0.33† (0.15)</td>
<td>0.38* (0.16)</td>
<td>0.36* (0.14)</td>
</tr>
<tr>
<td>Relational trust</td>
<td>0.06 (0.07)</td>
<td>0.06 (0.07)</td>
<td>0.07 (0.07)</td>
<td>0.04 (0.07)</td>
<td>0.04 (0.06)</td>
</tr>
<tr>
<td>H1: Structural holes * frequency</td>
<td>-0.33 (0.51)</td>
<td></td>
<td></td>
<td>-0.98† (0.52)</td>
<td></td>
</tr>
<tr>
<td>H2: Structural holes * closeness</td>
<td></td>
<td>2.42* (1.14)</td>
<td></td>
<td>0.85 (1.80)</td>
<td></td>
</tr>
<tr>
<td>H3: Structural holes * trust</td>
<td></td>
<td></td>
<td>1.66** (0.56)</td>
<td>1.89* (0.90)</td>
<td></td>
</tr>
</tbody>
</table>

\[ R^2 = .540 \hspace{1cm} .539 \hspace{1cm} .542 \hspace{1cm} .546 \hspace{1cm} .547 \]

Note: Unstandardized coefficients shown, with robust standard errors in parentheses, based on a random coefficient regression model using hierarchical linear modeling (HLM). \( N = 346 \) observations. All variables grand-mean centered.

\[ \hat{p} < .10; \] \( p < .05; \] \( ** p < .01; \] \( *** p < .001. \)
TABLE 3
HLM Regression Results for Receipt of Useful Knowledge: Problem Reformulation

<table>
<thead>
<tr>
<th></th>
<th>Model 6</th>
<th>Model 7</th>
<th>Model 8</th>
<th>Model 9</th>
<th>Model 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same age</td>
<td>0.01 (0.07)</td>
<td>0.02 (0.07)</td>
<td>0.01 (0.07)</td>
<td>0.01 (0.07)</td>
<td>0.02 (0.07)</td>
</tr>
<tr>
<td>Same gender</td>
<td>0.27** (0.10)</td>
<td>0.26* (0.11)</td>
<td>0.28** (0.11)</td>
<td>0.27* (0.11)</td>
<td>0.26* (0.12)</td>
</tr>
<tr>
<td>Same race/ethnicity</td>
<td>0.22 (0.24)</td>
<td>0.21 (0.23)</td>
<td>0.22 (0.24)</td>
<td>0.22 (0.24)</td>
<td>0.20 (0.22)</td>
</tr>
<tr>
<td>Physical proximity</td>
<td>0.03 (0.03)</td>
<td>0.03 (0.03)</td>
<td>0.03 (0.02)</td>
<td>0.03 (0.03)</td>
<td>0.04 (0.02)</td>
</tr>
<tr>
<td>Perceived competence</td>
<td>0.27*** (0.06)</td>
<td>0.27*** (0.06)</td>
<td>0.27*** (0.06)</td>
<td>0.27*** (0.06)</td>
<td>0.26*** (0.06)</td>
</tr>
<tr>
<td>Communication in person</td>
<td>0.23† (0.12)</td>
<td>0.22† (0.12)</td>
<td>0.24† (0.12)</td>
<td>0.25† (0.12)</td>
<td>0.24† (0.12)</td>
</tr>
<tr>
<td>Relationship length</td>
<td>0.09 (0.12)</td>
<td>0.08 (0.11)</td>
<td>0.08 (0.12)</td>
<td>0.07 (0.12)</td>
<td>0.04 (0.12)</td>
</tr>
<tr>
<td>Shared perspective</td>
<td>0.35*** (0.07)</td>
<td>0.35*** (0.07)</td>
<td>0.34*** (0.07)</td>
<td>0.35*** (0.07)</td>
<td>0.36*** (0.07)</td>
</tr>
<tr>
<td>Structural holes</td>
<td>-0.05 (2.28)</td>
<td>0.13 (2.17)</td>
<td>-1.35 (2.17)</td>
<td>-1.22 (2.35)</td>
<td>-1.15 (1.92)</td>
</tr>
<tr>
<td>Interaction frequency</td>
<td>0.02 (0.04)</td>
<td>0.02 (0.04)</td>
<td>0.02 (0.04)</td>
<td>0.01 (0.04)</td>
<td>0.03 (0.03)</td>
</tr>
<tr>
<td>Closeness</td>
<td>-0.25 (0.20)</td>
<td>-0.25 (0.20)</td>
<td>-0.27 (0.19)</td>
<td>-0.25 (0.20)</td>
<td>-0.25 (0.19)</td>
</tr>
<tr>
<td>Relational trust</td>
<td>0.36*** (0.09)</td>
<td>0.36*** (0.09)</td>
<td>0.36*** (0.09)</td>
<td>0.33*** (0.09)</td>
<td>0.33*** (0.08)</td>
</tr>
<tr>
<td>H1: Structural holes * frequency</td>
<td>-0.77 (0.51)</td>
<td></td>
<td></td>
<td>1.75 (1.58)</td>
<td>-1.45* (0.56)</td>
</tr>
<tr>
<td>H2: Structural holes * closeness</td>
<td></td>
<td></td>
<td>1.75 (1.58)</td>
<td></td>
<td>-0.26 (2.45)</td>
</tr>
<tr>
<td>H3: Structural holes * trust</td>
<td></td>
<td></td>
<td>1.78* (0.72)</td>
<td>2.56** (0.95)</td>
<td></td>
</tr>
</tbody>
</table>

\[ R^2 = .465 \quad .465 \quad .467 \quad .475 \quad .480 \]

Note: Unstandardized coefficients shown, with robust standard errors in parentheses, based on a random coefficient regression model using hierarchical linear modeling (HLM). \( N = 334 \) observations. All variables grand-mean centered.

† \( p < .10 \); * \( p < .05 \); ** \( p < .01 \); *** \( p < .001 \).
APPENDIX: Survey Items

Outcome Variables

For both types of useful knowledge, instructions said: “Please respond for each person using a scale from a Very Negative to a Very Positive contribution, with NA meaning you did not receive anything like this from this person on this task/project.”

Solutions. Sometimes when we consult with people, we benefit from their ability to provide specific answers to our question or solutions to our problems. To what extent did this person’s specific answers or input contribute to your performance on [name of task/project]? (1 = very negative, 2 = negative, 3 = somewhat negative, 4 = neither positive/negative, 5 = somewhat positive, 6 = positive, 7 = very positive, NA [recoded as missing value])

Problem reformulation. Sometimes when we consult with people, we benefit from their helping us think through a problem (even when they may not have specific information that solves our original problem). These interactions may help us consider important dimensions of a problem and/or anticipate issues likely to appear in the future. To what extent did this kind of problem-solving assistance from this person contribute to your performance on [name of task/project]? (1 = very negative, 2 = negative, 3 = somewhat negative, 4 = neither positive/negative, 5 = somewhat positive, 6 = positive, 7 = very positive, NA [recoded as missing value])

Predictor Variables

Same age. Relative to yours, what is this person’s age? (1 = younger than me by more than 5 years; 2 = my age plus or minus 5 years; 3 = older than me by more than 5 years; 4 = don’t know) [recoded as 1 = same age +/- 5 years; 0 = different age].

Same gender. What is this person’s gender? (1 = male; 2 = female) [recoded as 1 = same gender as respondent; 0 = different gender].

Same race/ethnicity. Do you consider this person to be the same race/ethnicity as you? (1 = yes; 2 = no) [recoded as 0 = no].

Physical proximity. Please indicate each person’s physical proximity to you during your work on [name of task/project]. (1 = worked immediately next to me, 2 = same floor and same hallway, 3 = same floor but different hallway, 4 = different floor, 5 = different building, 6 = different city, 7 = different country) [item reverse-coded].

Perceived competence. This person is very capable at the work he or she performs. (1 = strongly disagree; 2 = disagree; 3 = somewhat disagree; 4 = neutral; 5 = somewhat agree; 6 = agree; 7 = strongly agree).

Communication in person. During [name of task/project], what is the main way you have communicated with this person? (1 = in person; 2 = on-line (such as via the Internet or an intranet); 3 = by telephone; 4 = other) [recoded as 1 = in person; 0 = all others].

Relationship length. How long have you known each person? [logarithm of the number of months].
**Shared perspective.** This person and I share the same perspective, in that we think in a similar way, have similar goals and objectives, and understand each other’s language/jargon when we communicate. (1 = strongly disagree; 2 = disagree; 3 = somewhat disagree; 4 = neutral; 5 = somewhat agree; 6 = agree; 7 = strongly agree).

**Structural holes.** For the calculation of structural holes around each tie, we asked respondents about the closeness of their direct ties (see below for closeness) and indirect ties: “Please continue to use this scale to rate how well this person knows the others. 1 = Especially close—in the sense that they are one of each other’s closest personal contacts; 2 = Relationships that are somewhere between “especially close” and “distant.”; 3 = Distant—in the sense that they are total strangers or do not enjoy one another’s company.” [reverse-coded scale as 2, 1, 0]

**Interaction frequency.** How often have you communicated with each person since starting on [name of task/project]? (1 = daily; 2 = twice a week; 3 = once a week; 4 = twice a month; 5 = once a month; 6 = once every 2nd month; 7 = once every 3 months or less) [item reverse-coded].

**Closeness.** This next section deals with the relationship between you and the sources of information you listed in the first part of the questionnaire. It will also ask you to consider their relationships with each other. To start with you, how well do you know each of your sources? Please rate each relationship on the following scale. 1 = Especially close—in the sense that this person and I are one of each other’s closest personal contacts; 2 = Relationships that are somewhere between “especially close” and “distant.”; 3 = Distant—in the sense that this person and I are total strangers or do not enjoy each other’s company. [reverse-coded scale as 2, 1, 0]

**Relational trust.** This person is very concerned about my welfare. (1 = strongly disagree; 2 = disagree; 3 = somewhat disagree; 4 = neutral; 5 = somewhat agree; 6 = agree; 7 = strongly agree).